THE EFFECT OF TEMPERATURE ON THE ABSORPTION AND FLUORESCENCE SPECTRA OF IMPURITY CRYSTALS

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(Plate IX)

ABSTRACT. The absorption and fluorescence spectra of green Anthracene crystal at different temperatures were studied. At -180°C (liquid oxygen temperature) a new absorption band has been observed and at this temperature the fluorescence bands get sharper. As the temperature is lowered below room temperature the absorption bands become more and more intense and fluorescence bands sharper. At temperatures above room temperature the intensity of fluorescence bands diminishes and absorption bands grow weaker and weaker with rise of temperature.

INTRODUCTION

From studies of the absorptions and fluorescence spectra of single crystals of green anthracene the following important results were obtained previously (1944, 1945) by the author :—

(1) The positions and number of fluorescence bands of naphthacene are independent of exciting wavelength as long as the wavelength is not longer than its lowest absorption band.

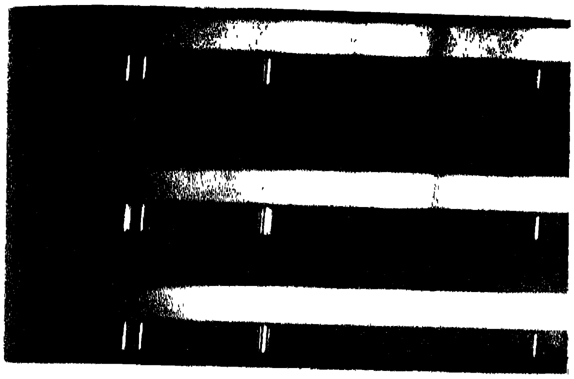
(2) If the crystal is excited by strong ultra-violet radiations from a Hg. arc (3650, 4047Å) in addition to the characteristic bands of naphthacene we get four more fluorescence bands which are due to anthracene.

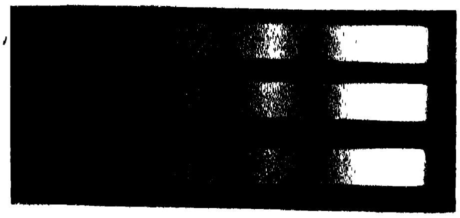
(3) With the change of frequency of incident radiation we find a change of intensity of the fluorescence bands ; the intensity is greater when the incident light wave is an absoption band of the substance. The change of intensity is practically the same for all the fluorescence bands of the substance.

As the study of absorption and fluorescence spectra at different temperatures is expected to give much valuable information about the nature of the physical process involved in emission of fluorescence spectra and as the study at low temperature has been confined so far on powdered substances (1939) we have undertaken the study of fluorescence and absorption of a single crystal at different temperatures including low temperature.

EXPERIMENTAL

Absorption at low temperature.—A single crystal of Anthracene with slight traces of Naphthancene is taken. It is mounted on a copper plate (with a groove inside) attached at the end of a thin copper rod. The copper plate with the crystal in the groove is now introduced into a long narrow pyrex tube. A





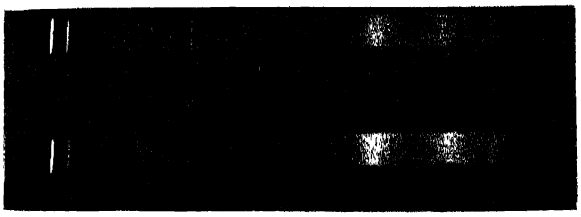


Fig. 3

Fig. 4

Absorption Spectra of Napthacene in Solid solution of Anthracene.

Fig. 1. : (a) at 30 c. (b) at 117 c. (c) at 180 c.

Fig. 2. : (a) at 30 c. (b) at 50 c. (c) at 75 c.

Fluorescent Spectra of Napthacene in Solid solution of Anthracene

Fig. 3. : (a) at 30 c. (b) at 180°c.

Fig. 4. : (a) at 30 c. (b) at 50°c. (c) at 75°c.

copper plate just fitting the lower end of the interior of the tube and projected upward has been introduced for conduction. The whole is now immersed into a double walled vacuum flask. White light from a coiled-coil lamp is focussed on the crystal by means of a condensing lens. The transmitted light is received on the slit of the spectrograph. The absorption spectra at 30°C, 0°C, −10°C, −117°C, −180°C is taken. For 0°C, the lower end of the pyrex tube was filled with ice, for −10°C it was filled with ice and salt, for −117°C, it was filled with solidified alcohol, and for −180°C liquid oxygen is taken in a dewar flask. The temperature is recorded by a pentane thermometer. The Fig. (1) of Plate X shows the absorption bands at various temperatures. Time for each exposure is the same and current flowing in the lamp is kept fairly constant. Besides the continuous absorption bands shorter than 405 $m\mu$, we find absorption band at 435, 460, 491 $m\mu$ which are all due to naphthacene.

Absorption at high temperature.—The crystal is mounted on the groove in a thick copper disc. The disc is placed well inside an electric heater both ends of which are open. For uniform heating a hollow copper cylinder both ends of which are open is inserted inside the heater. The heater is held horizontally and adjusted so that light from a coiled coil lamp passes through the crystal. The transmitted light is received on the slit of a Fuess spectrograph. By adjusting the resistance which is connected in series with the heater the current is adjusted. By inserting a thermometer the temperature is recorded. When the temperature becomes steady exposure is started. The current in the lamp is kept fairly constant all through the experiment. Time for each exposure is the same and photographs at different temperatures are taken on the same plate. (Fig. 2).

Fluorescence Spectra at Low Temperature.—The crystal is mounted in the same way as it was mounted for absorption experiment. Light from a mercury arc is condensed on the crystal and between lens and the crystal a filter transmitting 4047 A, 3650 A, is interposed. The fluorescent radiation with the transmitted incident light is received on the slit of the Fuess Spectrograph. The fluorescent spectra at room temperature (30°C) and liquid oxygen temperature (−180°C) are shown in Fig. (3).

Fluorescence Spectra at High Temperature.—The crystal is mounted exactly in the same manner as it was mounted for absorption spectra at high temperature. The ordinary lamp is replaced by a mercury arc lamp and between the mercury arc and the crystal a filter is interposed which transmitted only 3650, 4047 A. Light from the Hg. arc is condensed on the crystal by means of a condenser. The condenser should be placed between the filter and the Hg. arc. By adjusting the resistance which is connected in series with the heater the current is adjusted. By suitable adjustment of resistance we maintained 50°C and 75°C temperature inside the heater. When the temperature becomes steady exposure is given. Photographs are taken on the same plate and time for each exposure is the same (Fig. 4).

RESULT

Besides the continuous absorption bands shorter than 405 $m\mu$ we find absorption bands at 435, 460, 491 $m\mu$ which are all due to naphthacene. From visual observation it is quite evident that with the decrease of temperature, from room temperature the bands get sharpened. At liquid oxygen temperature we observe a new absorption band which is very sharp, on the shorter wave-length side of 491 $m\mu$, its actual wave-length being 486 $m\mu$. On careful inspection of the photograph it will be revealed that there is another absorption band on the shorter wavelength side of this new absorption band. That is due to liquid oxygen. The blank exposure shows the presence of it. As the crystal was surrounded by liquid air it is clear that this is due to liquid air. The temperature was raised from 30°C to 50°C, and hence to 75°C. It is found that the intensity of the absorption bands gradually diminishes with the rise of temperature.

Naphthacene has three fluorescence bands at 408, 533, 574 $m\mu$. From the plate it is evident that as the temperature is lowered below room temperature the bands get sharper and the intensity slightly diminishes, when the temperature is raised above room temperature, the intensity of fluorescence bands also gradually diminishes.

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REFERENCES

S. C. Ganguly (1944), *Nature*, **153** 652.
S. C. Ganguly (1945), *J. Chem. Phys*, **13**, 128.
J. T. Randall (1939), *Trans. Faraday Soc.*, **35**, 2.